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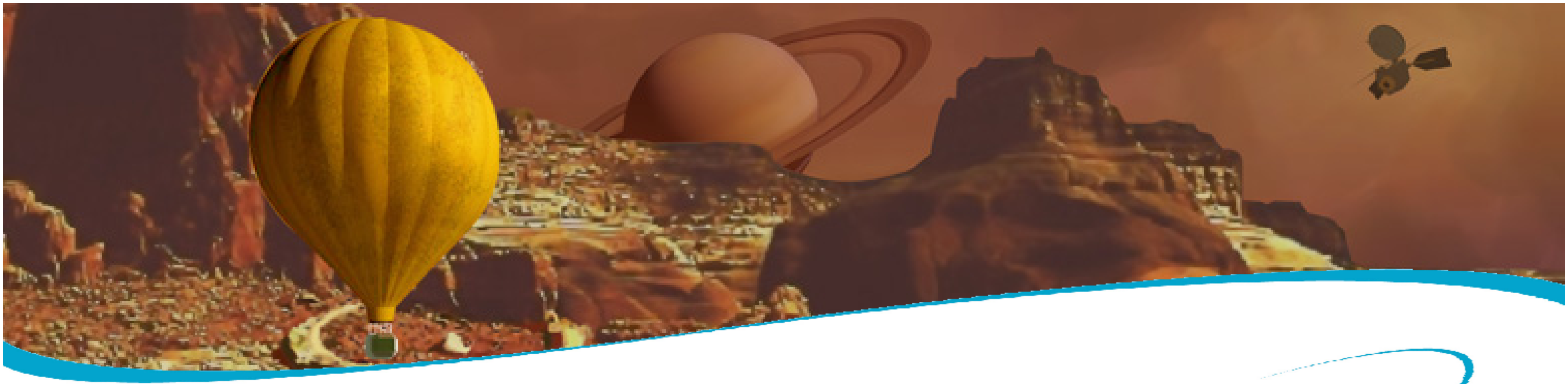

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TITAN probes following CASSINI - HUYGENS

Denis LEBLEU

Template reference : 100181708K-EN

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Back to TITAN

24/06/2008

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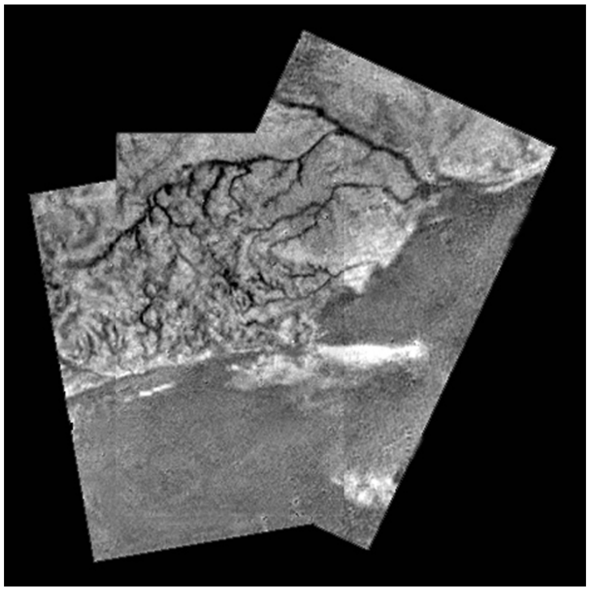
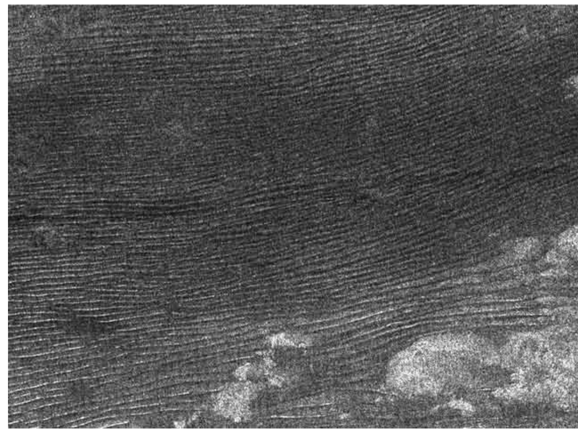
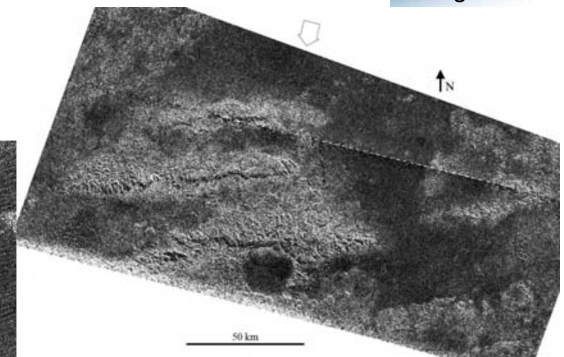
CASSINI – HUYGENS has revealed a complex world



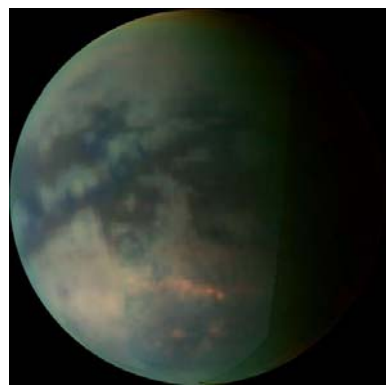
Fluvial system (ESA/NASA/University of Arizona)



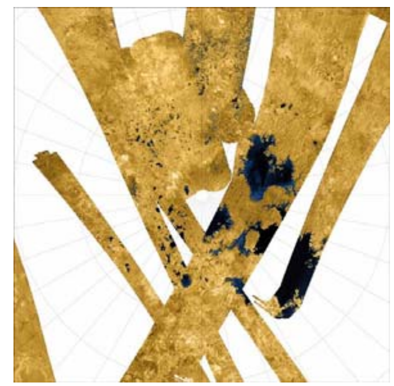
Dunes ➔ ground-wind interaction (NASA/JPL)



Tectonic ? (NASA/JPL)



Clouds (NASA/JPL)



Lakes (NASA/JPL)

TITAN as a System (TANDEM Cosmic Vision team)

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Electrical power is the key constraints

- **Sun power is almost null on TITAN surface ➔ Solar arrays are discarded**

- **Long lived lander - Radio-isotopic generator**
  - MMRTG ➔ 120W for 40kg
  - Stirling converter ➔ 110W for 30kg
  - Thermo-electric generator (4W) ➔ 4W for few kg

- **Short life mission**
  - Primary battery ➔ 60kg power system on HUYGENS
  - Secondary battery ➔ Limitation on Coast phase duration

- **Using TITAN resource**
  - Gas turbine (CH_4 available … but needs to bring O_2 !)
  - Wind ! About 1m/s on ground for 1.5 bar pressure

- **Power demand and mission duration drives the power system choice … and the probe mass budget**

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Target instruments wrt mass budget

- **Scientific demand drives Vehicle design**
  - Extensive payload
  - High power demand (even time sharing) lead to radioisotopic generator (either MMRTG or Stirling SRG) ➔ Landed Mass !
  - Number of instruments lead to complex on-board computer ➔ Landed mass
  - High landed mass ➔ large parachute and perhaps landing shock absorber (airbags or crushable structure) ➔ Mass
  - High landed mass and Descent System mass lead to large Heatshield ➔ Mass

Classical snowball effect on Entry Probes

- **If affordable on the Orbiter wrt Launched mass, only a unique probe**
- **HUYGENS:**
  - 5 instruments
  - 320 kg
  - Only 3 hours

➔ **Reach (some?) scientific objectives with lower mass**

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Probe with similar objective than HUYGENS

- **Entry Descent and Landing**
  - Similar ballistic coefficient as HUYGENS (32 kg/m²) ➔ But could be increased
  - Heatshield - Moderate entry velocity (6km/s or lower)
    - Low density ablator as thermal protection ➔ experience from EXOMARS
    - Thermal protection necessary characterization wrt UV thermal radiative flux
      - CASSINI/HUYGENS data on atmosphere chemical composition allow to reduce the risk associated to this environment
    - Classical structure

➔ Entry system: **TRL 7 to 8**

  - Parachute system downscaled from HUYGENS, complemented by EXOMARS

➔ Descent system: **TRL 7 to 8**

  - Low landing velocity as HUYGENS (5m/s)➔ No landing system

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- **Surface module**
  - Power generation
    - Primary batteries lead to high mass budget (necessary redundancy) ➔ reduce instrument allowed mass
    - ThermoElectric Generator combined with RHU could provide limited power, allowing transient operation
      - 100% of the time, TEG charge a secondary battery
      - TBC% of the time, on the battery, science & telecommunication
    - RITEC TEG developed in Russia for Mars96, studies performed for EXOMARS Geophysical Package (GEP) with better efficiency ~4W (electrical)
    - Potential common development within AURORA: EXOMARS or MARSNEXT

➔ RITEC system: **TRL 7 to 8**

➔ European design: **TRL 3 to 4 TBC**

  - Thermal control inherit of HUYGENS experience, complemented with EXOMARS Rover developments: Insulation and RHU

➔ Thermal control: **TRL 8**

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Surface module

- Electronic integrated design for:
  - mass optimization
  - Share benefit of thermal dissipation
  - Reduce harness & Connector (mass and loss)

➔ Avionic: **TRL 6 reachable**

Preliminary Mass Budget

- 100kg probe is reachable
- 8 kg devoted to instruments (Order of magnitude)
- Still large uncertainties on power system: Battery is not mass efficient

Power is still the critical technology

	TITAN probe
Entry & Descent	
Aeroshell	44,8 kg
Separation mechanisms	6,6 kg
Descent system	17,7 kg
Thermal	3,8 kg
Surface module	
Structure	5,5 kg
Thermal	6,6 kg
Power	4,0 kg
DHS	1,3 kg
Telecom	1,6 kg
Instruments	8,2 kg
TOTAL	**100,0 kg**

Back to TITAN

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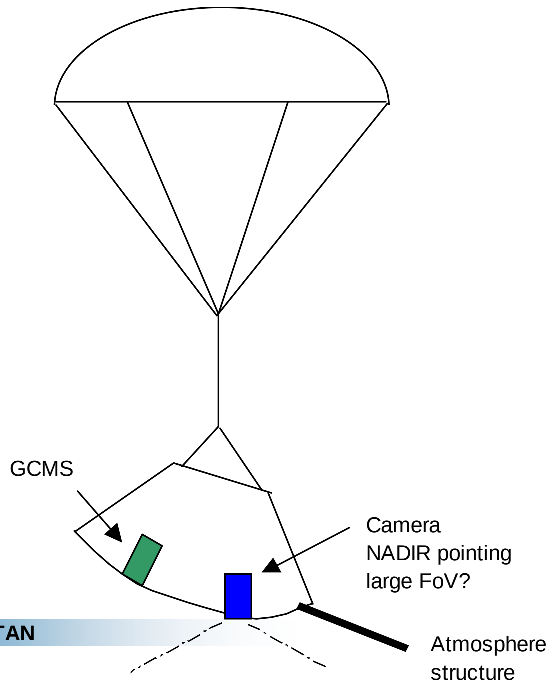
Targeting a polar area - lakes

- Objective is surface composition ➔ GCMS = ~ 4kg
- Separation from Orbit induces Short coast phase + no necessary long descent (as HUYGENS) + short duration on ground (~30 minutes for GCMS operation)
  - ➔ Classical secondary batteries compatible with the need : More mass efficient than HUYGENS primary batteries
- First iteration - 1,2m diameter Frontshield / ~ 65kg / Mission duration ~2 hours



- Minimize mass: Single parachute ➔ no Back cover separation
- Descent instruments looking NADIR ➔ commonality descent science & science in liquid (spectrometer) ➔ consider HUY lessons learned
- Antennas within Back cover TPS (ExoMars experience)
- Mechanical design allowing splash down
- Thermal control is a concern: Convection in liquid more efficient than in gas

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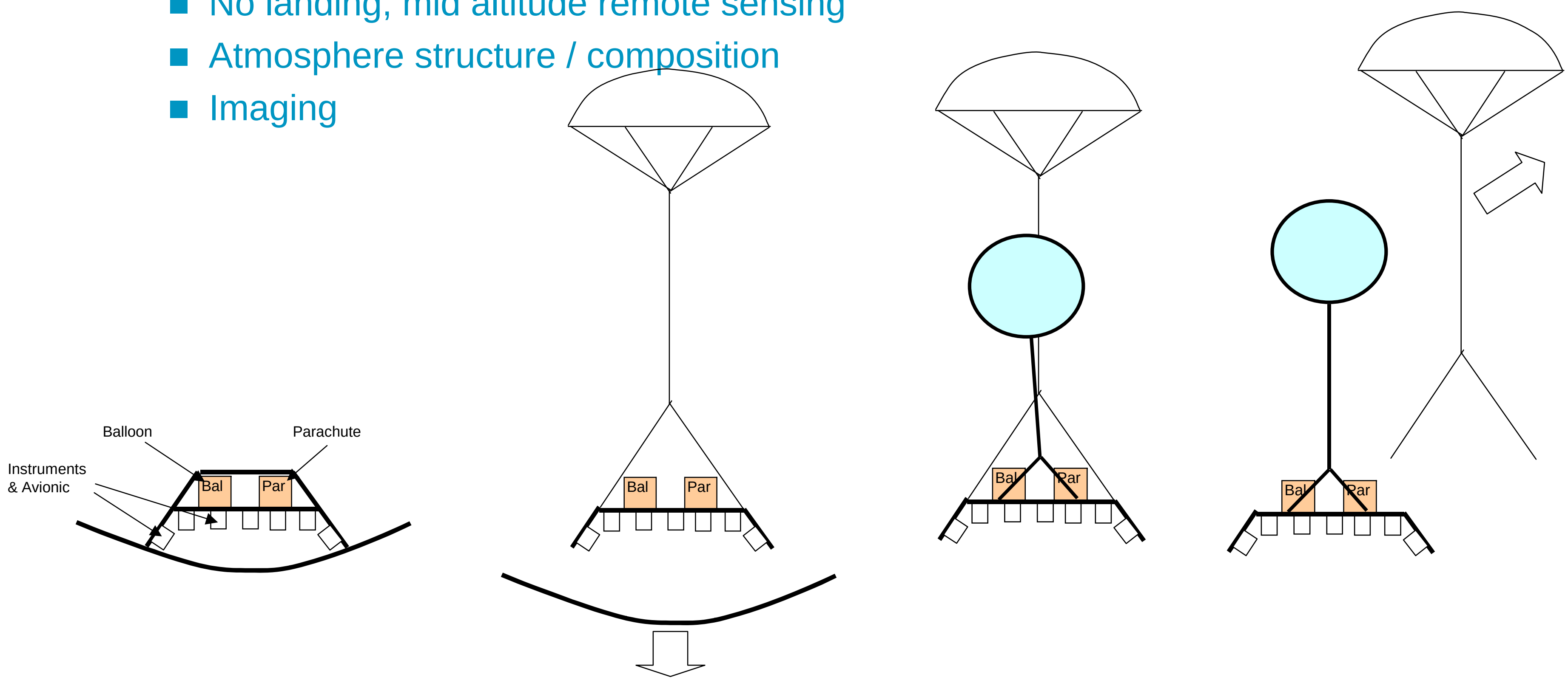
Small balloon delivered at different latitude

- **As a complement or replace montgolfiere**
  - No landing, mid altitude remote sensing
  - Atmosphere structure / composition
  - Imaging



ENTRY in TITAN Atmosphere — **Frontshield separation Mach 0,8** — **Balloon Deployment** — **Mission under balloon**

  - Mass budget around 110kg - assuming 40kg for Balloon + Avionic + instruments (~5kg)

Back to TITAN

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- **Lander concept**
  - Crude information: data represented by tones (Temp., Pressure, Wind velocity)
  - Only hardware: No soft, no computer
  - Thermal control with few RHU
  - Completely autonomous
  - Power generation: Use what is available on Titian = Wind !
  - Data transmission when wind, or just survive

- **Wind power generator**
  - Small windmill for mobile phone
    - Earth for V > 4m/s
    - Windmill coupled with battery
  - Power need just for telecom (4W)
    - 30cm windmill coupled with battery/condenser
    - 1 tone / 2 minutes (to be consolidated …)
  - Deposit by montgolfiere / self deployment

  - Is it sufficient for science ?

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Descent – From ~150km to Ground

- Which science during Descent Drives the Descent velocity

Instrument	HUYGENS	Integration time
GCMS	GCMS / ACP	Significantly long
Imager	DISR	Short
Accelerometer	HASI	Very short
Atmosphere structure	HASI	Continuous

- Device (parachute or other) providing drag **only** to cross transonic and release the Frontshield
  - Descent velocity ~200m/s ➔ 13 minutes … no landing
  - Significant mass gain ➔ Target around 60kg

- Tune the probe design to the science objectives ➔ Atmosphere sampling in the range [0km ; 150 km] really necessary after HUYGENS ?

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Conclusion

- **Science requirement drives the vehicle design and mass**
  - Power need
  - Mission duration

- **Alternative to unique large probe can be implemented**
  - 100kg probe to medium latitude
  - 70 kg probe to pole
  - 110kg balloon
  - 4 to 5 kg meteorology station

- **Need for development of a low mass/low power radio-isotopic device**
  - TEG within Europe, RHU based
  - Valuable for TITAN, but also for MARS

- **HUYGENS has included an efficient suite of instruments (very good complementary in Huygens Data Analysis Workshop)**
  - Probe with HUYGENS up to date instrument but at an other location (pole, cryo-volcano, dunes, …), not reachable by the montgolfiere could be a good compromise

Back to TITAN

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